System of Environmental Economic Accounting

SEEA Experimental Ecosystem Accounting; Applications of the SEEA

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Objectives of the Session

- Overview of the SEEA Experimental Ecosystem Accounting
- Linking SEEA with SDGs
- Indicators
- Linking SEEA with Input-Output Analysis

SEEA Experimental Ecosystem Accounting

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One Environment: Two Perspectives

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Central Framework:
Individual Environmental Assets/Resources

- Timber
- Water
- Soil
- Fish

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Experimental Ecosystem Accounts:
Ecosystem Assets (spatially based)

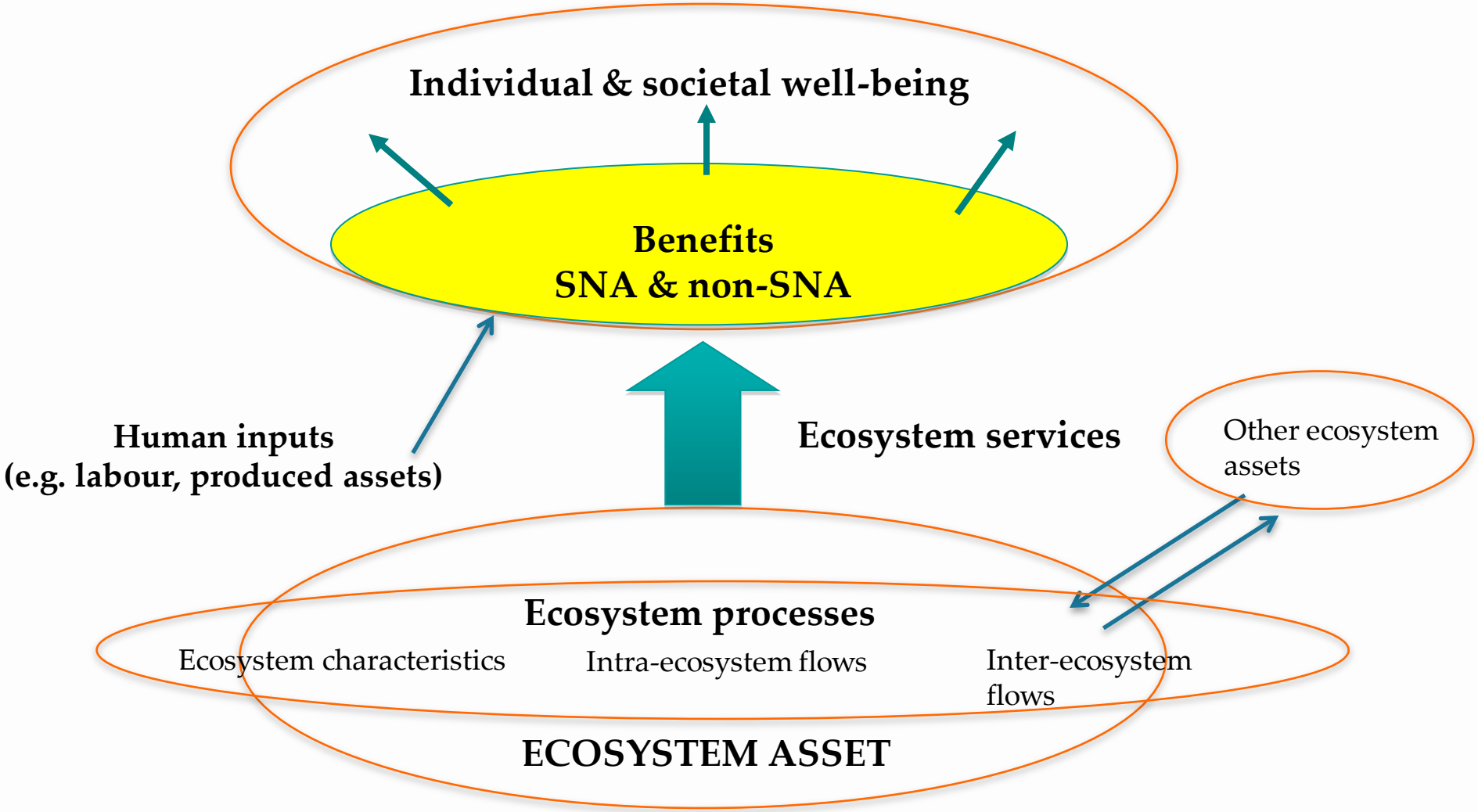
- Forests
- Lakes
- Agricultural areas

Ecosystem Assets are environmental assets viewed from a systems perspective

SEEA Experimental Ecosystem Accounting (SEEA EEA)

- An integrated accounting framework for ecosystem stocks (assets) and flows (services)
  - Measures the contributions of ecosystem to economic and other human activity
  - Takes a detailed spatial approach (geography and statistics)
- A synthesis of current knowledge on ecosystem services, ecosystem condition and related concepts
  - "Experimental" because significant measurement challenges remain and further testing of concepts is needed

Ecosystem Accounting model



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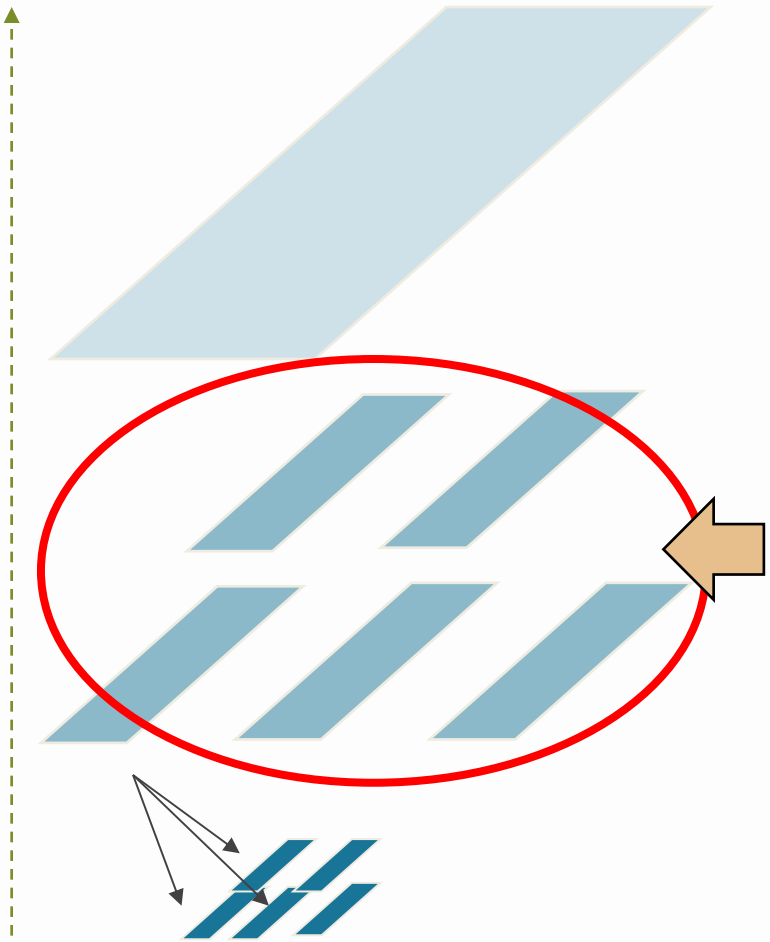
Statistical units

Geographical aggregation

Ecosystem Unit (EU)

Basic Spatial Unit (BSU)

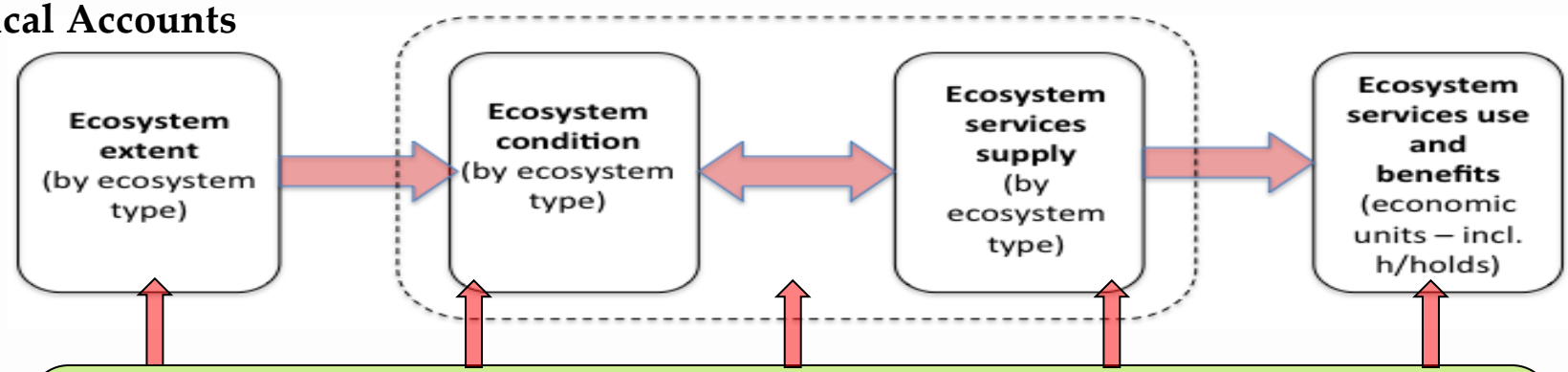


Ecosystem units

- Spatial areas that form the conceptual base for accounting and the integration of relevant statistics.
- Delineation is based on ecological characteristics
- Where various ecological data are not available, a land cover based delineation can be used as a starting point

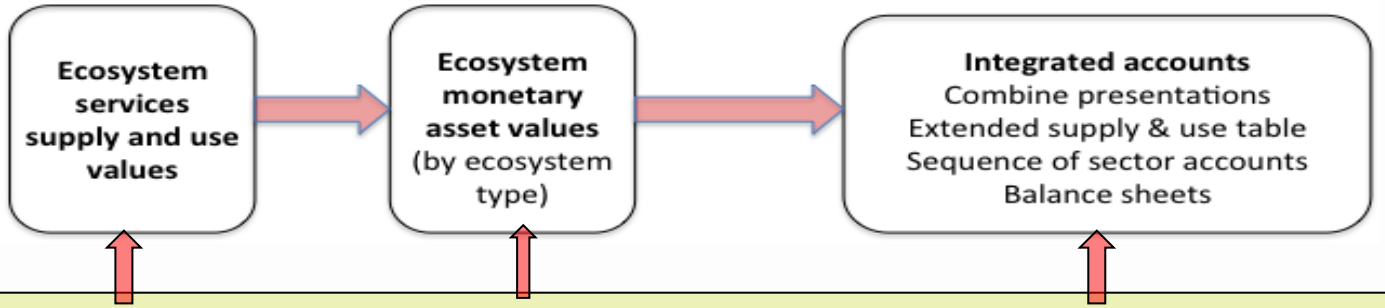
Broad steps in ecosystem accounting

a. Physical Accounts



Ecosystem thematic accounts: Land, Carbon, Water, Biodiversity
Supporting information: Socio-economic conditions and activities, ecological production functions
Tools: classifications, spatial units, scaling, aggregation, biophysical modelling
Source: Official statistics, spatial data, remote sensing data

b. Monetary Accounts



Supporting information: SNA accounts, I-O tables
Tools: Valuation techniques

Ecosystem condition

Table 4.4 Changes in ecosystem condition for an LCEU

		Characteristics of ecosystem condition				
		Vegetation	Biodiversity	Soil	Water	Carbon
		Indicators (e.g. Leaf area index, biomass, mean annual increment)	Indicators (e.g. species richness, relative abundance)	Indicators (e.g. soil organic matter content, soil carbon, groundwater table)	Indicators (e.g. river flow, water quality, fish species)	Indicators (e.g. net carbon balance, primary productivity)
Opening condition						
Improvements in condition						
	Improvements due to natural regeneration (net of normal natural losses					
	Improvements due to human activity					
Reductions in condition						
	Reductions due to extraction and harvest of resources					
	Reductions due to ongoing human activity					
	Catastrophic losses due to human activity					
	Catastrophic losses due to natural events					
Closing condition						

Using basic measures, can derive table of changes in condition.

Could also be done by referencing each indicator to a reference condition.

Ecosystem extent account

	Type of Ecosystem Unit															
	Artificial surfaces	Herbaceous crops	Woody crops	Multiple or layered crops	Grassland	Tree-covered areas	Mangroves	Shrub-covered areas	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow and glaciers	Inland water bodies	Coastal water and inter-tidal areas	Sea and marine areas	TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Opening extent																
Additions to extent																
Managed expansion																
Natural expansion																
Upward reappraisals																
Reductions in extent																
Managed regression																
Natural regression																
Downward reappraisals																
Net change in extent																
Closing extent																

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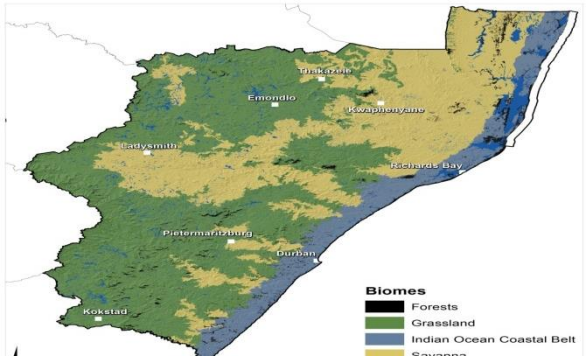
Example: South African pilot study - Ecosystem extent accounts (by biome) for KZN



Hectares	Grassland	Savanna	Indian Ocean Coastal Belt	Wetland	Forest
Opening balance 1840	4 581 933	3 259 059	893 967	393 718	202 822
Total reductions in stock	1 651 736	840 380	528 754	107 567	18 208
Total reductions as a % of 1840	36	26	59	27	9
Opening balance 2005	2 930 197	2 418 679	365 213	286 151	184 614
Total reductions in stock	277 108	208 607	59 723	18 276	9 792
Total reductions as a % of 1840	6	6	7	5	5
Opening balance 2008	2 653 090	2 210 072	305 490	267 875	174 822
Total reductions in stock	68 092	34 757	11 782	9 082	3 128
Total reductions as a % of 1840	1	1	1	2	2
Opening balance 2011	2 584 998	2 175 315	293 708	258 793	171 694

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Source:

Driver, A., Nel, J.L., Smith, J., Daniels, F., Poole, C.J., Jewitt, D. & Escott, B.J. 2015. Land and ecosystem accounting in KwaZulu-Natal, South Africa. Discussion document for Advancing SEEA Experimental Ecosystem Accounting Project, October 2015. South African National Biodiversity Institute, Pretoria.

Ecosystem condition account

(End of accounting period)

Type of Ecosystem Unit	Ecosystem characteristics						
	Vegetation	Water resources	Soil	Carbon	Biodiversity	Air	...
Artificial surfaces							
Herbaceous crops							
Woody crops							
Multiple or layered crops							
Grassland							
Tree-covered areas							
Mangroves							
Shrub-covered areas							
Regularly flooded areas							
Sparse natural vegetated areas							
Terrestrial barren land							
Permanent snow and glaciers							
Inland water bodies							
Coastal water and inter-tidal areas							
Sea and marine areas							

Example: An Experimental Ecosystem Account for the Great Barrier Reef Region 2015 by ABS

TABLE 3.5: VEGETATION CONDITION, BY NRM TERRESTRIAL REGION, GREAT BARRIER REEF REGION, 2000-01 to 2011-12, Index (2000-01 = 100)

NRM Region	2000-01 g C/m^2/day	2000-01 points	2001-02 points	2002-03 points	2003-04 points	2004-05 points	2005-06 points	2006-07 points	2007-08 points	2008-09 points	2009-10 points	2010-11 points	2011-12 points
Burdekin	1.70	100	68	53	63	50	72	73	106	106	95	131	100
Burnett Mary	1.90	100	87	105	116	93	101	72	117	114	110	148	125
Cape York	2.12	100	99	82	88	91	90	103	99	104	88	111	99
Fitzroy	1.84	100	71	80	82	69	81	64	119	107	108	151	112
Mackay Whitsunday	3.59	100	89	74	84	75	83	87	99	90	88	93	97
Wet Tropics	3.11	100	102	91	91	95	93	102	104	106	96	100	98
Total GBR Region	**2.38**	**100**	**88**	**81**	**88**	**80**	**87**	**86**	**106**	**103**	**96**	**117**	**103**

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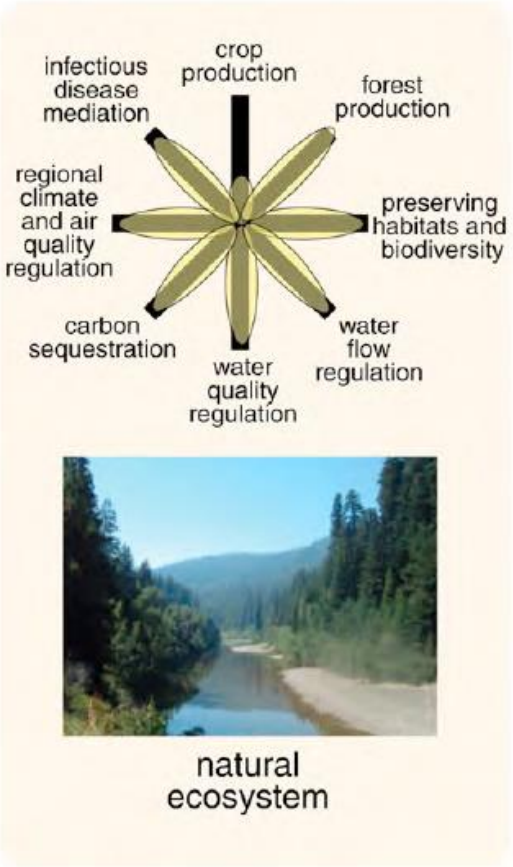
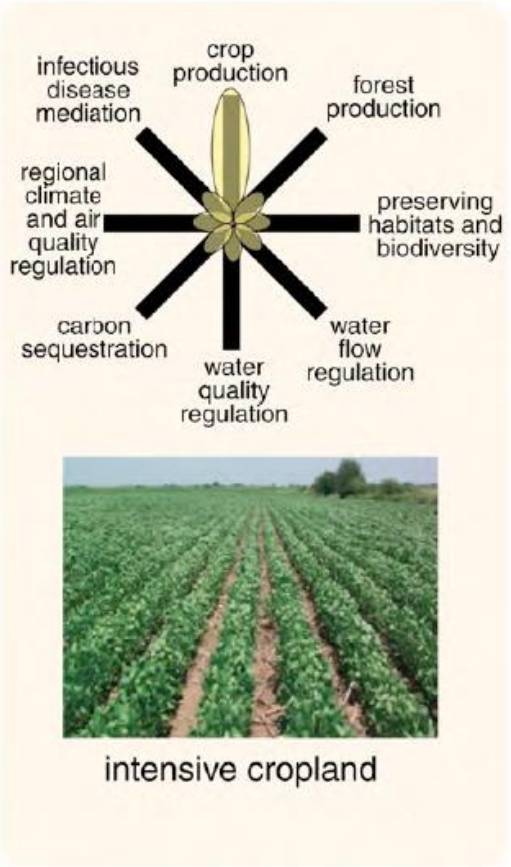
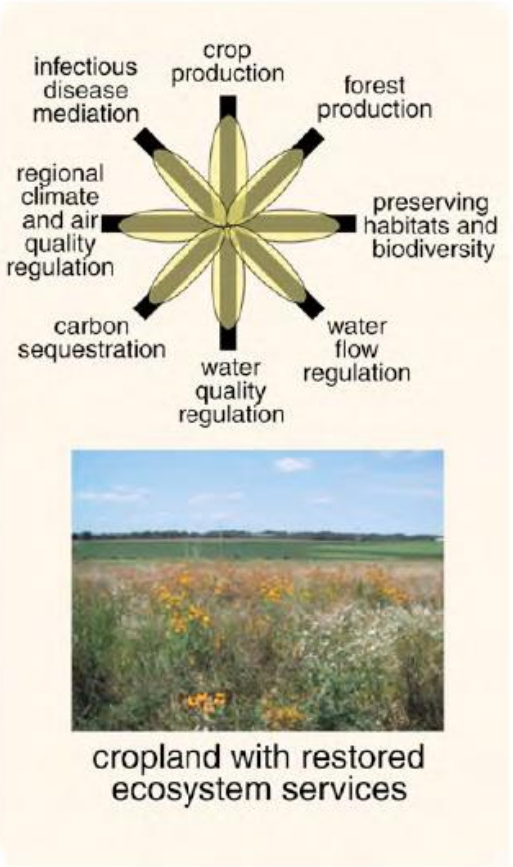
Source: *Information Paper: An Experimental Ecosystem Account for the Great Barrier Reef Region 2015*
http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/4680.0.55.001Main%20Features12015?opendocument&tabname=Summary&prodno=4680.0.55.001&issue=2015&num=&view=

Expected bundle of ecosystem services







(Foley et al. 2005 Science)

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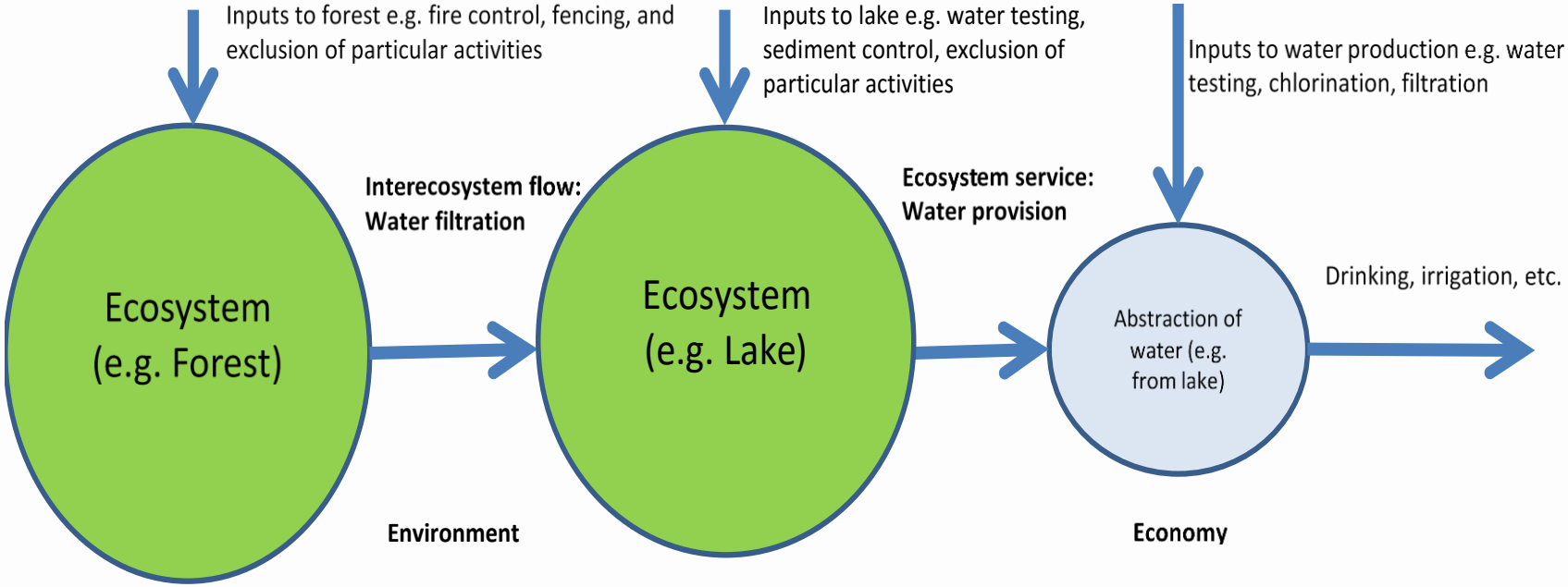
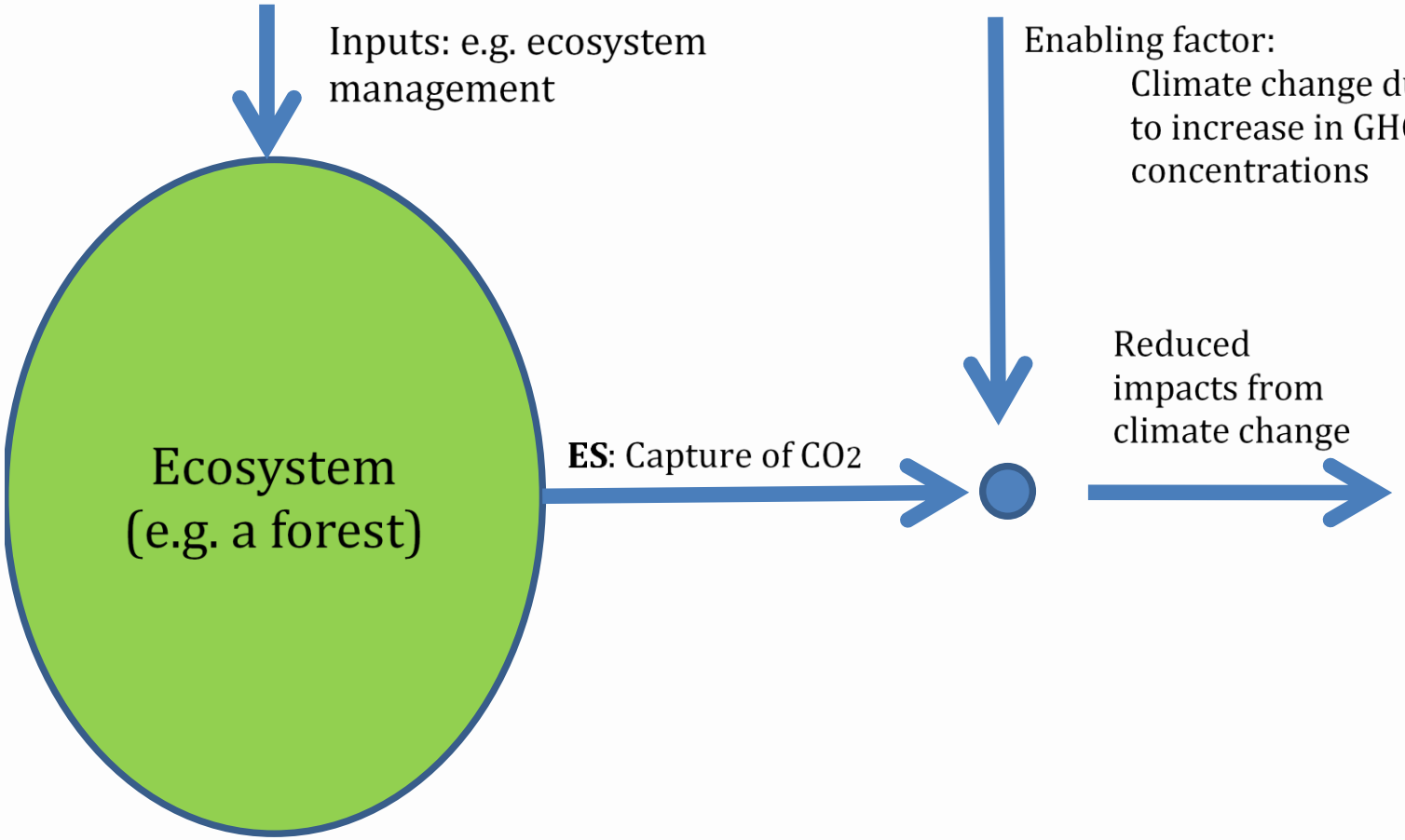
Ecosystem services: Water Provisioning



- SEEA only accounts for the final ecosystem service of water provisioning

Ecosystem services: carbon sequestration



Source: SEEA-EEA, Fig. A3.4, p. 71

Ecosystem services supply and use table

ECOSYSTEM SERVICES SUPPLY TABLE

	UNITS	Type of economic unit							Type of Ecosystem Unit															TOTAL SUPPLY
		Agriculture, forestry and fisheries	Electricity, gas supply	Water collection, treatment and supply	Other industries	Households	Accumulation	Rest of the world - Imports	Artificial surfaces	Herbaceous crops	Woody crops	Multiple or layered crops	Grassland	Tree-covered areas	Mangroves	Shrub-covered areas	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow and glaciers	Inland water bodies	Coastal water and inter-tidal areas	Sea and marine areas	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15								
Ecosystem services Provisioning services Regulating services Cultural services		A							B															
Products		C							D															

ECOSYSTEM SERVICES USE TABLE

	UNITS	Type of economic unit							Type of Ecosystem Unit															TOTAL USE
		Agriculture, forestry and fisheries	Electricity, gas supply	Water collection, treatment and supply	Other industries	Households	Accumulation	Rest of the world - Exports	Artificial surfaces	Herbaceous crops	Woody crops	Multiple or layered crops	Grassland	Tree-covered areas	Mangroves	Shrub-covered areas	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow and glaciers	Inland water bodies	Coastal water and inter-tidal areas	Sea and marine areas	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15								
Ecosystem services Provisioning services Regulating services Cultural services		E							F															
Products		G							H															

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Thematic accounts

- Standalone accounts on topics of interest in their own right
- Direct relevance in the measurement of ecosystems and in assessing policy responses.
- Thematic accounts include accounts for land, carbon, water and biodiversity.

Example: Carbon Accounting in Australia

Primary reservoir	Geocarbon (Mt C)	Hectares (million)	Biomass carbon (Mt C)	Soil organic carbon (Mt C)	Total biocarbon (Mt C)
Biocarbon					
Natural ecosystems					
Rangelands		596.3	6,374	6,603	12,977
Non rangelands:					
Eucalypt native forests		16.7	4,671	3,753	8,424
Shrub lands & woodlands		14.7	500	636	1,137
Grass, shrub & heath lands		1.6	37	51	87
Rainforests		2.3	1,225	252	1,477
Other		0.7	15	16	32
Marine ecosystems		1.8	114	1,084	1,198
Fresh water ecosystems		9.9	4	7	11
Total Natural ecosystems		**644.0**	**12,941**	**12,402**	**25,343**
Semi-natural ecosystems					
Highly modified rangelands		50.0	750	1,500	2,250
Grazing in modified pastures outside rangelands		32.9	132	1,315	1,447
Total Semi-natural ecosystems		**82.9**	**882**	**2,815**	**3,697**
Agricultural ecosystems					
Cropping		25.5	102	1,022	1,124
Irrigated agriculture		2.6	12	105	117
Plantation wood		2.4	177	120	296
Reservoir/dam		0.6	1	6	7
Other		6.3	120	244	363
Total Agriculture ecosystems		**37.4**	**412**	**1,497**	**1,907**
Settlements		2.6	30	79	108
Other		0.5	7	19	26
Total Settlements and Other		**3.1**	**37**	**98**	**134**
Total biocarbon[d]		**767.4**	**14,270**	**16,811**	**31,081**

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Source:
https://coombs-forum.crawford.anu.edu.au/publication/hc-coombs-policy-forum/4708/carbon-accounting-australia

Broad steps in ecosystem accounting

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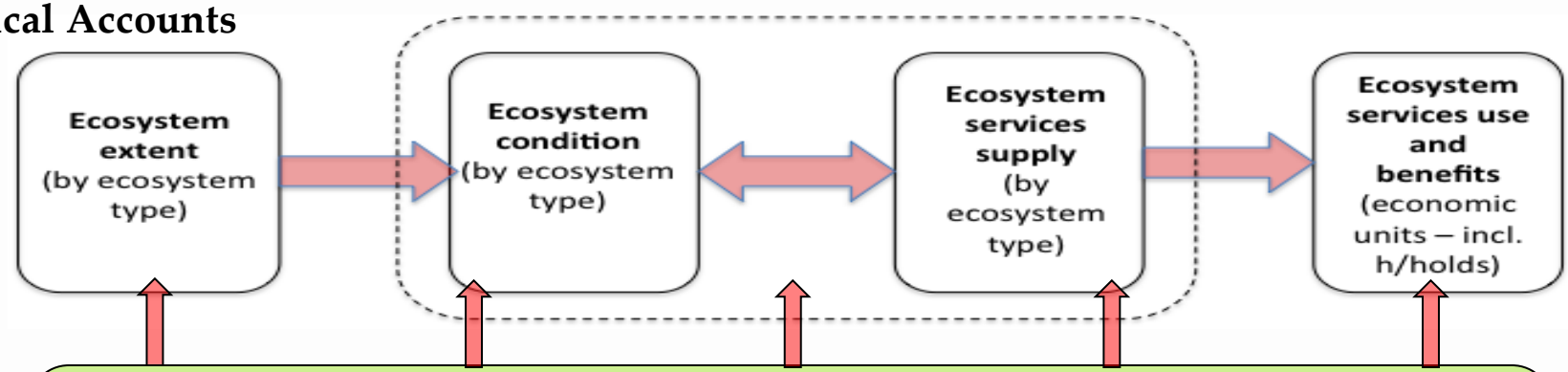

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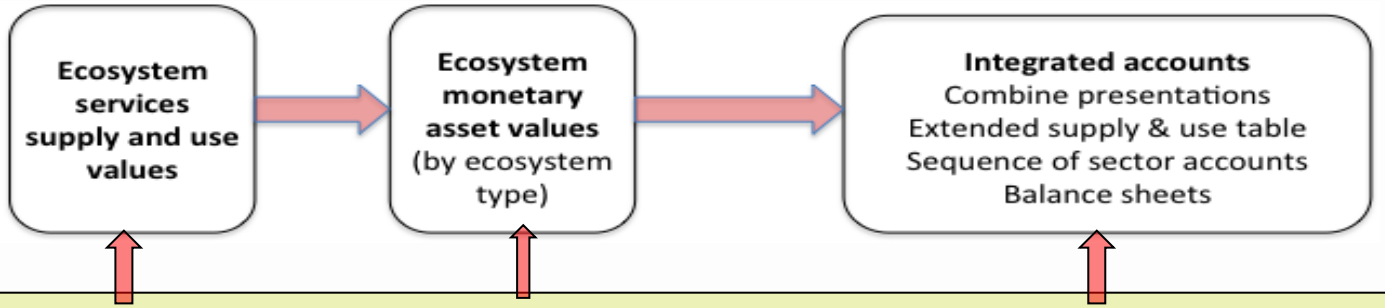

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Linking SEEA with SDGs

Methodological Consistency for SDGs: An Integrated Architecture

- Integration of the SDG indicator framework requires methodological consistency across themes and levels of monitoring.
- This methodological consistency should be supported by statistical frameworks such as the SNA and SEEA.
- Indicators based on statistical frameworks benefit from:
- Aligned definitions and classifications
- Coherence when combining environmental and economic statistics
- A common and comprehensive approach to disaggregation
- Including for all component statistics of an indicator
- International comparability

Scope of alignment

- 41 of the indicators currently under discussion by the IAEG-SDGs can be defined according to the SNA and SEEA

Sustainable Development Goals	# indicators informed by SNA & SEEA		Sustainable Development Goals	# indicators informed by SNA & SEEA	
2) Zero Hunger	2	(/10)	11) Sustainable Cities and Communities	3	(/11)
6) Clean Water & Sanitation	5	(/9)	12) Responsible Consumption & Production	3	(/11)
7) Affordable & Clean Energy	4	(/6)	14) Life below Water	6	(/10)
8) Decent Work & Economic Growth	4	(/15)	15) Life on Land	9	(/13)
9) Industry, Innovation & Infrastructure	3	(/10)	17) Partnerships	1	(/20)
10) Reduced Inequalities	1	(/12)	1, 3, 4, 5, 13, 16	None	(/71)

Methodological Consistency for SDGs

	Material Flows & Solid Waste	Energy & Carbon Emissions	Water & Wastewater	Agriculture, Forestry & Fishery	Ecosystems	Land Use & Management
Efficiency/ Productivity in the use of Natural Resources	1. How do we define efficiency? How do we define productivity? 2. How do we measure efficiency/productivity in the use of natural resources? 3. How do we disaggregate and compare across sectors? 4. How do we juxtapose environmental and economic information to derive these indicators?					
Waste Minimization and Treatment	5. When is something considered waste? How is this defined? 6. How do we define reuse and recycling? How do we define 'regular collection', 'safe treatment' and 'good waste management'? 7. How do we disaggregate and compare this across sectors?					
Sustainability and Management of Resources	8. How do we define and compare economic uses of natural resources to their availability? 9. How do we classify and monitor management of those resources? 10. How do we use tools such as GIS and land accounting to inform this?					
Monetary Indicators	11. How do we measure and classify expenditure, taxes and subsidies on the management for different environmental issues?					

- The answers to these questions should be consistent across indicators.
- **Aligning indicators to the SEEA and SNA helps build this consistency**

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Alignment of Energy Indicators: Example

- Target 7.3: By 2030, double the global rate of improvement in energy efficiency
- Current Proposal: Rate of improvement in energy intensity (%) measured in terms of primary energy and GDP
- Why use the SEEA and SEEA-Energy?
  - Application of common accounting concepts and principals in the SEEA Energy and SNA allowing for coherence when combining physical and monetary information
  - A common and comprehensive basis for disaggregation of both the numerator (SEEA-Energy Accounts) and denominator (SNA) based on ISIC

SEEA Aligned Indicator: $\dfrac{\text{Energy End Use by Industries}}{\text{Gross Value Added by Industries (Constant Prices)}}$

Energy end use: The use of energy products in producing goods and services (intermediate consumption of energy by industry). (*Derived from the SEEA Supply and Use Tables for Energy.)*

Gross value added: The difference between output and intermediate consumption in constant prices.

Alignment of Water Indicators: Example

- Target 6.4. By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
- Current Proposal: Percentage change in water use efficiency over time
- Why use the SEEA and SEEA-Water?
  - A consistent definition of water use to be applied across sectors, and coherence in the way in which "value" is defined and measured across sectors
  - A common and comprehensive basis for disaggregation of both the numerator (from the SEEA PSUT for water) and denominator (SNA) based on ISIC

SEEA Aligned Indicator: $\frac{\text{Total Water Use}}{\text{Gross Domestic Product}}$

NOTE: This Indicator for the whole economy can be disaggregated by Economic Activity based ISIC when using the SEEA-Water accounting structure.

Total Water Use: Water intake of an economic unit. Water use is the sum of water use within the economy (i.e. one economic unit intaking water received through distribution from another economic unit.) and water directly abstracted from the environment.

Gross value added: The difference between output and intermediate consumption in constant prices.

Alignment of Sustainable Growth Indicators: Example

- Target 8.4: Improve progressively. through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead
- Current Proposal: Resources productivity

SEEA Aligned Indicator: $\frac{\text{Domestic Material Consumption}}{\text{Gross Domestic Product}}$

Domestic Material Consumption (DMC): is derived from economy-wide material flow accounts (EW-MFA) a physical flow account included in the SEEA-CF. DMC is defined as the domestic extraction of materials (excluding bulk flows of water and air) plus physical imports minus physical exports. DMC measures the total amount of materials (excl. bulk flows of water and air) that are directly/actually used in a national economy, i.e. by resident units

Alignment of Ecosystem Indicators: Example

- Target 15.1: By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements
- Current proposal: Forest area as a percentage of total land area

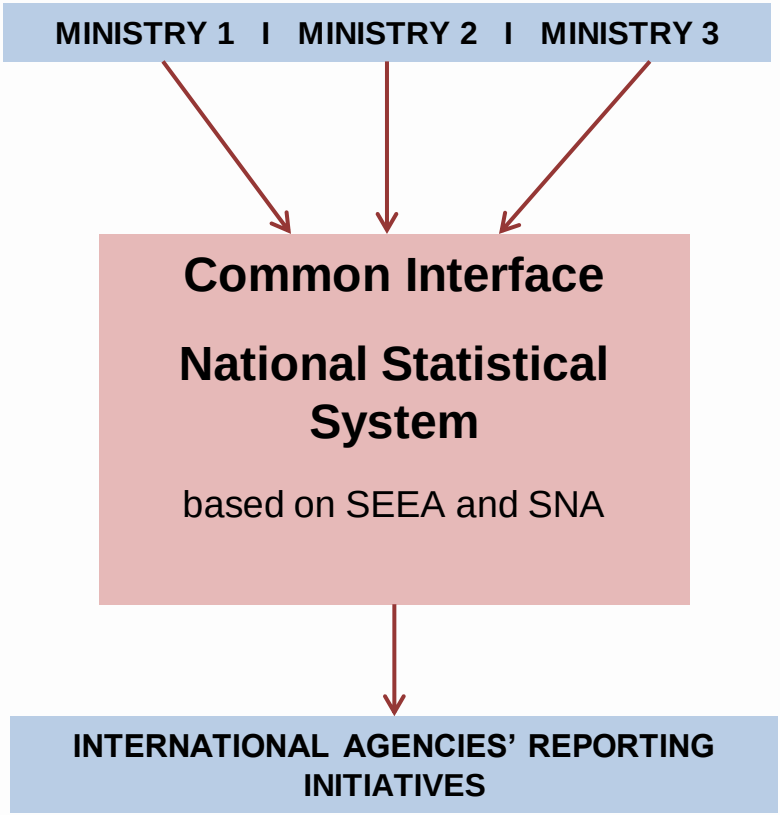
SEEA Aligned Indicator: $\frac{\text{Forest areas}}{\text{Total land area}}$

Forest areas: The area of forest land can be defined following two different perspective and the two should not be confounded. 1) Land cover ; 2) Land use perspective:

- The FAO Land Cover Classification System (LCCS) in the SEEA Central Framework provides a basis for defining and classifying any piece of land with rigorous syntax and clear classification criteria for land cover that can be supplemented with information on properties and characteristics of the basic objects.
- The Classification of Land Use provided in the SEEA Central Framework for detailed explanation of each forest land covered land used for forestry, natural conservation, water provision, etc.

Total country area is defined as the area enclosed by all inland borders and if applicable, the normal baselines (low-water mark) and straight baselines on the seaward side. In the SEEA Central Framework, land accounts encompass areas covered by terrestrial land and inland water resources such as river and lakes. In certain applications, the land accounts may be extended to include areas of coastal water and a country's exclusive economic zone.

SEEA: Streamlined Reporting for SDGs



Methodological Consistency resulting from implementation of the SEEA **reduces reporting burden** of national ministries/agencies:

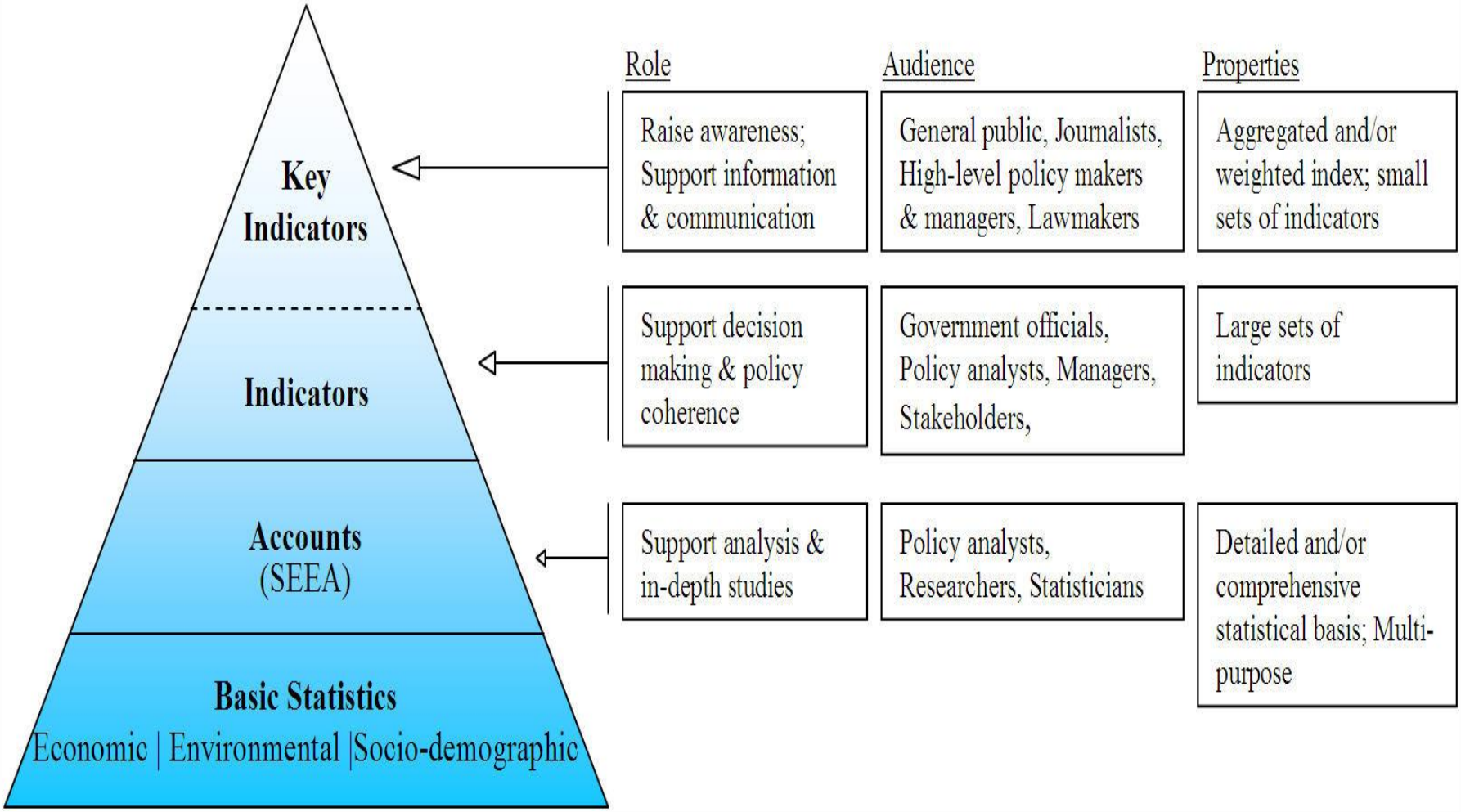
- Single Data System to Inform Indicators
- Data Compiled Once for Many Purposes
- Reduced need for countries to make arduous data adjustments for international reporting

Facilitates **streamlined reporting process for global SDG Indicators**

- Consistent definitions, classifications and spatial units at national and international level allows for **direct transmission of information**

Indicators

Indicators


Key Indicators
Indicators
Accounts (SEEA)
Basic Statistics
Economic | Environmental |Socio-demographic
Role
Audience
Properties
Raise awareness; Support information & communication
General public, Journalists, High-level policy makers & managers, Lawmakers
Aggregated and/or weighted index; small sets of indicators
Support decision making & policy coherence
Government officials, Policy analysts, Managers, Stakeholders,
Large sets of indicators
Support analysis & in-depth studies
Policy analysts, Researchers, Statisticians
Detailed and/or comprehensive statistical basis; Multi-purpose

Resource use and environmental efficiency

- Efficiency indicators compare trends in economic activity
  - such as value-added, income or consumption with trends in specific environmental flows such as emissions, energy and water use, and flows of waste

- Intensity indicators -- ratio of the environmental flow to the measure of economic activity

- Productivity indicators -- inverse of intensity.

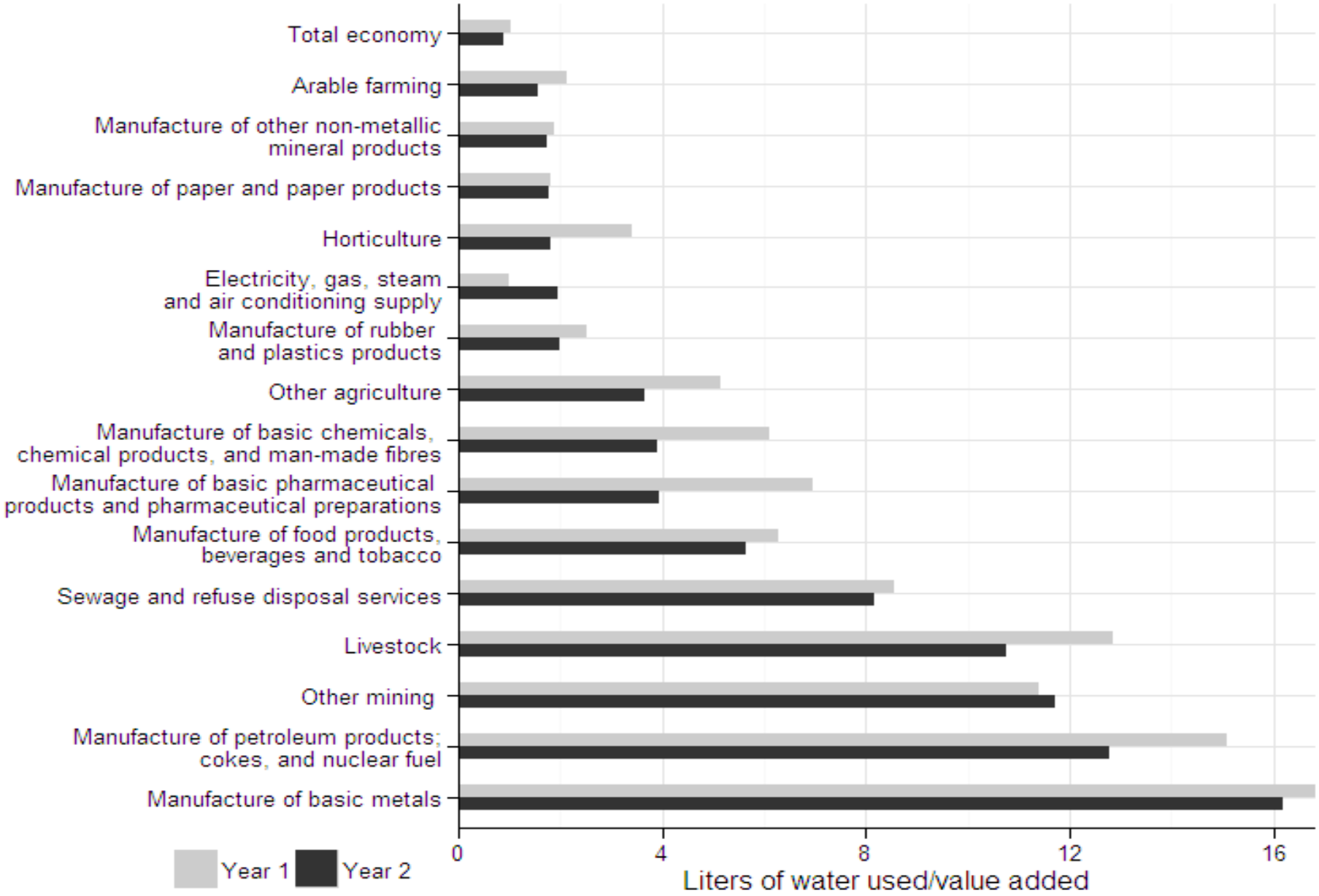
Resource use and environmental efficiency

- Efficiency indicators—two broad categories
- Environmental efficiency indicators
  - characterise the environmental and economic efficiency with which **pollutants and other residuals** generated in production and consumption are mitigated, controlled and prevented.
  - They are usually expressed as intensity or productivity ratios.
- Resource efficiency indicators
  - characterise the efficiency with which **natural resources**, including water, energy and other materials are used in production and consumption.
  - usually expressed as intensity or productivity ratios.
  - relate environmental variables such as the extraction, supply or consumption of natural resources and materials to economic variables such as output, income and value added.

Resource use and environmental efficiency

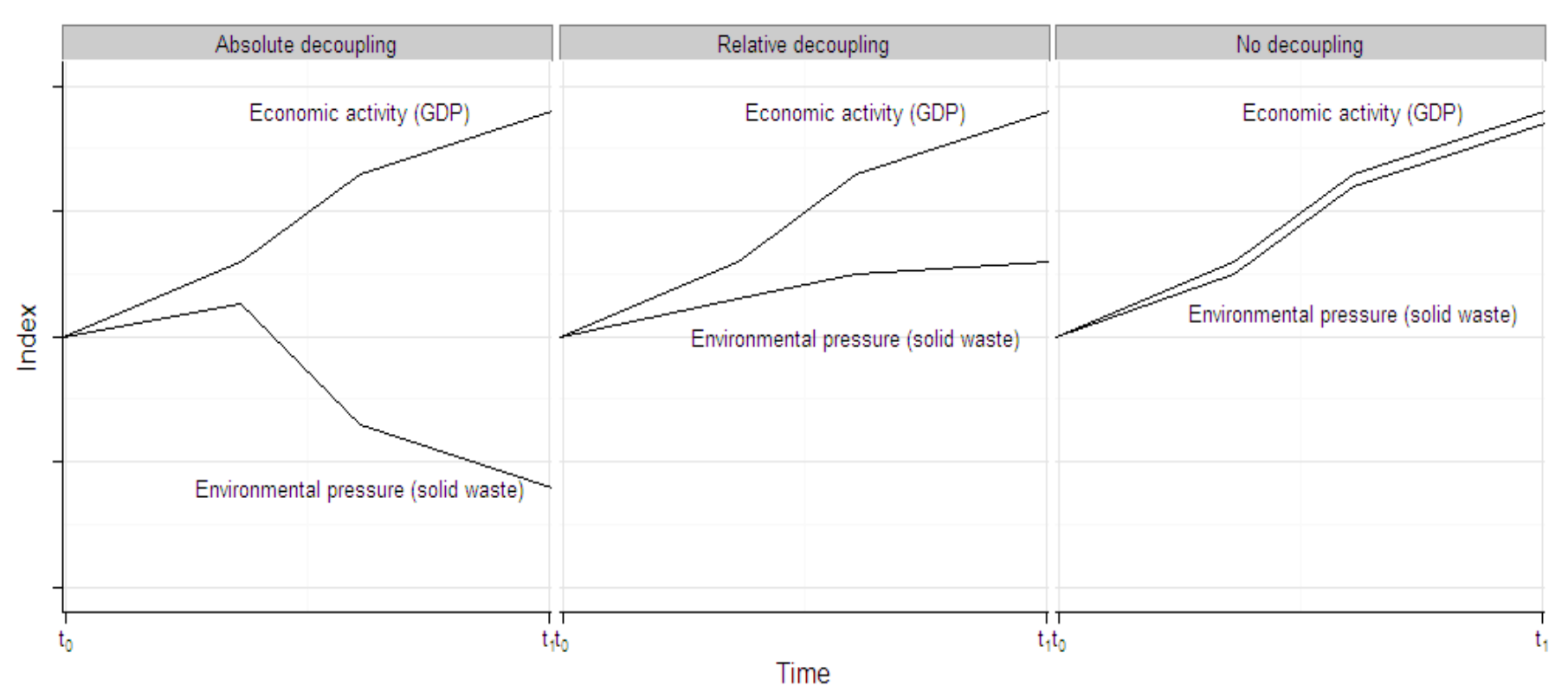
- Environmental efficiency indicators
  - Greenhouse Gas (GHG) or CO2 productivity
  - Air pollutant emission intensities
  - Water pollution intensities
- Resource efficiency indicators
  - Material productivity or intensity indicators
  - Energy productivity or intensity indicators
  - Water use productivity or intensity indicators

Example - Industry level water use intensity indicators

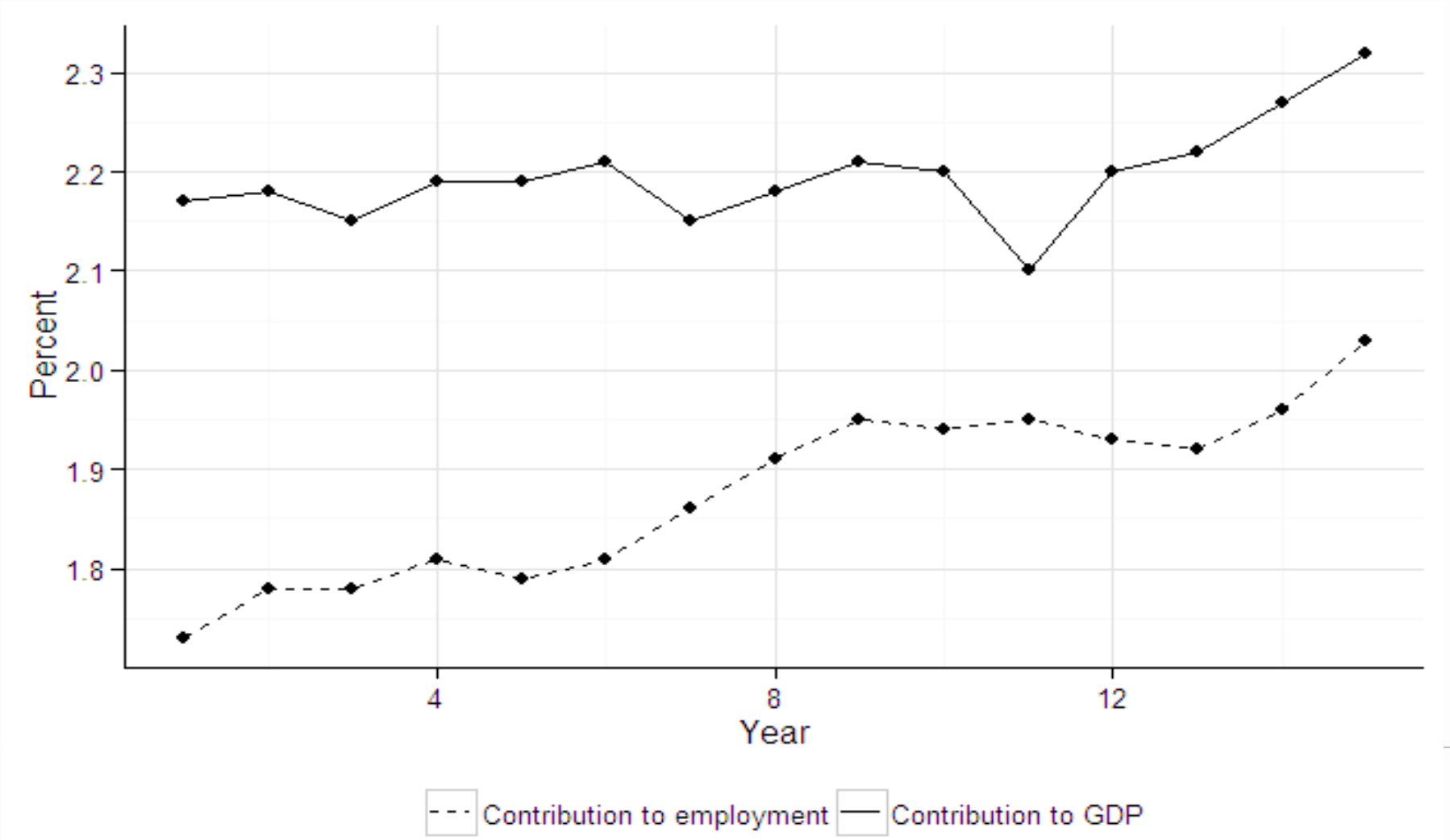


Resource use and environmental efficiency-decoupling

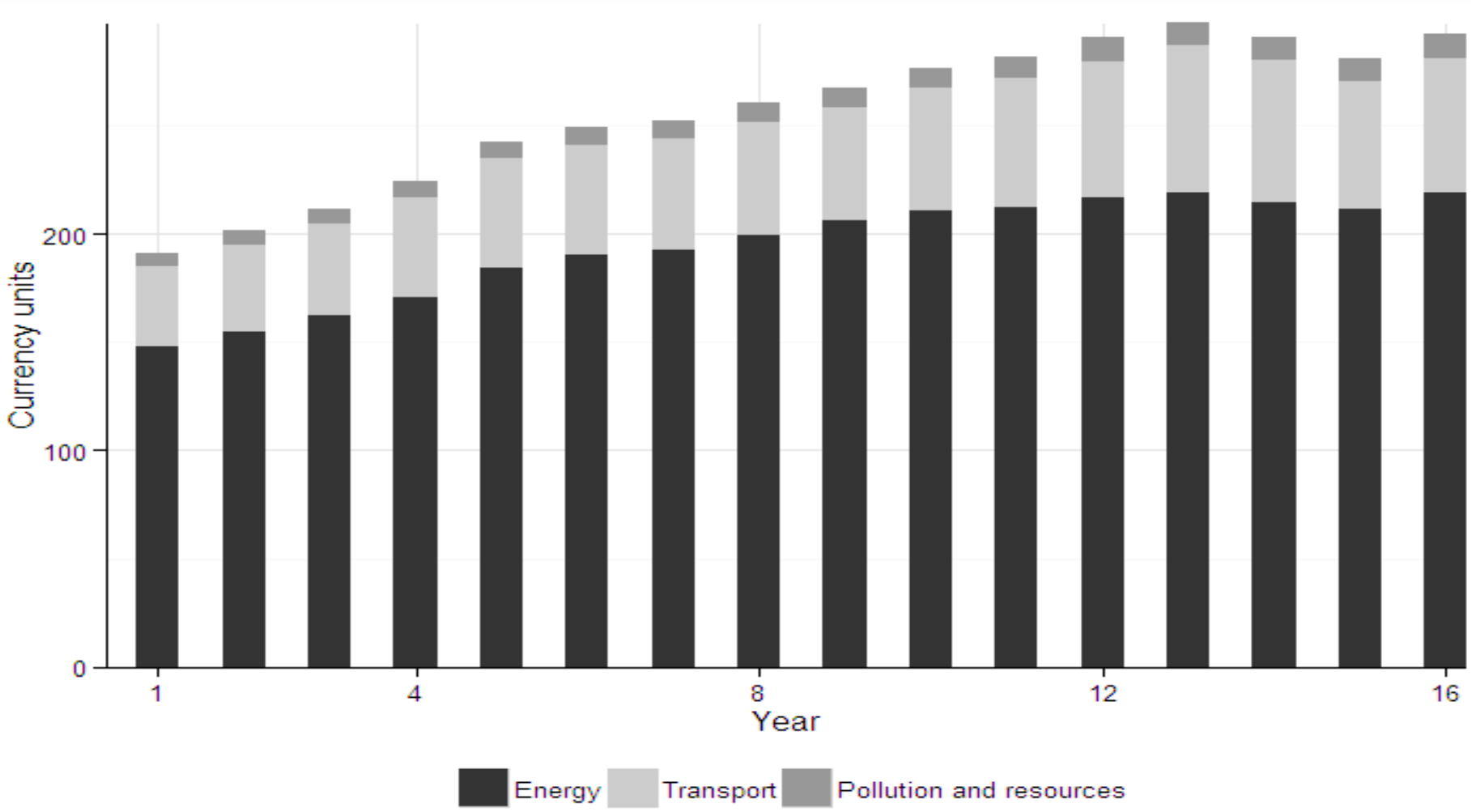
- Absolute: growth in the environmentally relevant variable is flat or decreasing while economic activity increasing
- Relative: growth rate of the environmentally relevant variable is positive but less than the growth rate of the economic variable



Example – EGSS contributions to GDP and employment



Taxes example: Environmental tax revenue by type



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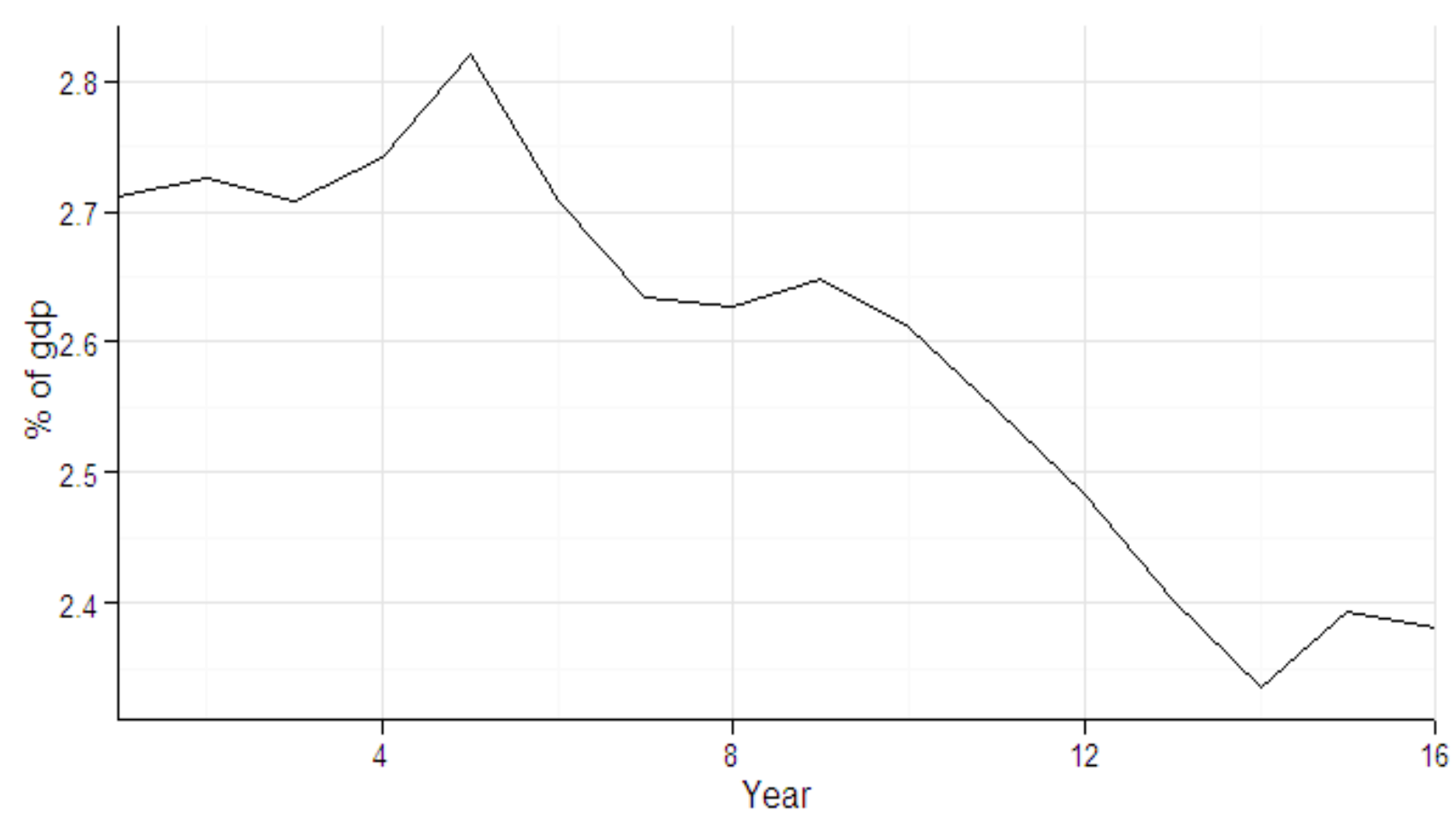
Taxes example: Environmental tax revenue as % of GDP



Example of indicators drawn from SEEA Energy and the national accounts

Measurement issue	Indicator	Data sources for the indicator	
		SEEA Energy	National accounts
Decoupling: Can economic growth happen without a similar increase in energy use?	Energy use per GDP	Physical supply-use tables for energy	Production account
Are expenditures on energy becoming relatively more or less burdensome for households?	Share of household income spent on fuel and electricity	Monetary supply-use tables for energy	Account for secondary distribution of income
How many years of energy extraction is left if extraction continues as now?	Resources-to-production ratio	Physical asset accounts for energy	
Is the economy weak sustainable?	Total national wealth	Monetary asset accounts for energy	Balance sheets

Linking SEEA with Input-output analysis

(Reference: Ole Gravgård, SEEA Training Seminar for the ECA Addis Ababa 2-5 February 2015)

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Input-output tables and analysis

- Input-output tables are used as the core of many macro-economic models

- Input-output tables is the basis of the input-output model that can give valuable information about the direct as well as indirect effects on production, employment, imports, air emissions etc. of changes in final demand.

Linking SEEA with Input-output analysis

What kind of questions can be answered by using input-output analysis?

- the direct and indirect share of agricultural production in total exports?
- What are the total direct and indirect effects on employment of increasing investment in construction by 10 pct?
- What are the total direct and indirect effects on energy production of increasing private consumption of meat by 1 million dollars?
- etc.

Linking SEEA with Input-Output Analysis

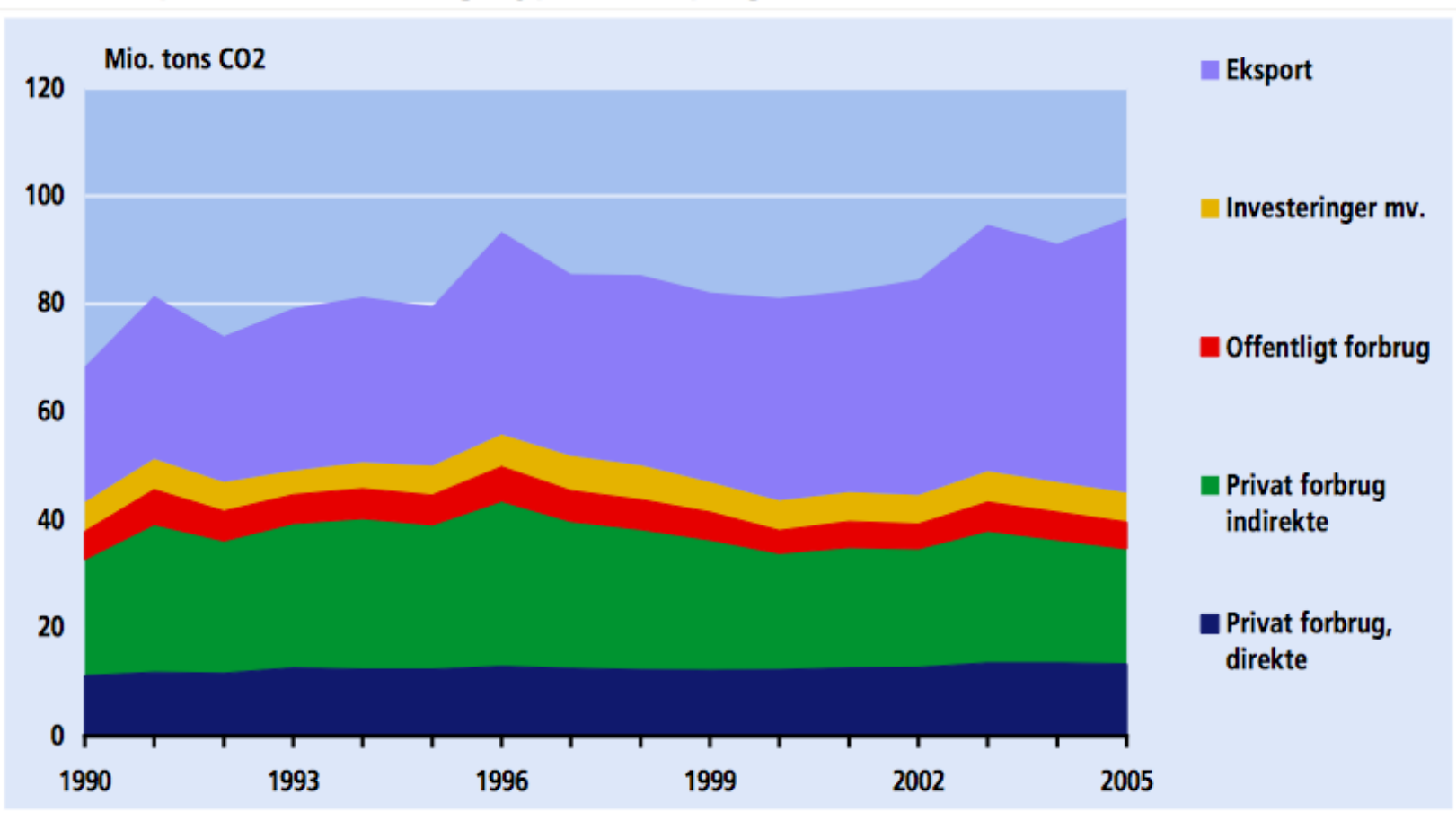
- For analytical purposes it is useful to link the information from the SEEA physical flow accounts with the input-output tables measured in monetary units (hybrid tables)

- Environmentally extended input-output tables (EE-IOT)

- This facilitates insight into the drivers of the environmental pressures and the indirect effects (footprints) of various economic activities

Examples of EE-IO modelling

DANISH CO2 EMISSION BY CAUSING ECONOMIC ACTIVITIES



An input-output table

	Intermediate consumption								Final demand					Total
DKK billions, current prices	1.Agriculture, fishing and quarrying	2.Manufacturing	3. Electricity, heat, gas and water supply	4. Construction	5. Trade, hotels and restaurants	6.Transport, post og telecommunications	7. Financial intermediation, business act.	8. Public and personal services	Private consumption	Public consumption	Gross fixed capital formation	Changes in stocks	Export	
1. Agriculture, fishing and quarrying	8	50	9	2	0	0	0	2	3	1	0	1	45	**121**
2. Manufacturing	13	96	1	37	17	7	14	10	49	1	29	7	292	**573**
3. Electricity, heat, gas and water supply	1	7	3	0	4	1	2	4	21	0	0	0	9	**51**
4. Construction	1	3	3	2	2	6	26	7	4	7	125	0	1	**187**
5. Trade, hotels and restaurants	5	30	0	21	15	8	6	10	148	3	22	1	75	**343**
6. Transport, post og telecommunications	1	14	0	2	33	35	17	18	36	1	2	0	163	**323**
7. Financial intermediation, business act.	8	35	3	27	50	18	96	42	193	5	29	0	30	**535**
8. Public and personal services	1	5	1	1	5	3	12	29	81	379	4	0	2	**524**
Import incl. costum duties	11	144	4	23	37	127	29	26	77	4	53	8	141	**684**
Taxes on products, net	3	3	0	2	5	6	17	24	132	2	40	0	-2	**233**
Use at market prices	**52**	**388**	**25**	**116**	**168**	**211**	**220**	**171**	**745**	**403**	**304**	**18**	**757**	**3576**
Other taxes on production, net	-5	-1	0	0	0	0	7	-4						
Compensation of employees	10	131	5	54	130	56	138	301						
Gross operating surplus and mixed income	65	56	22	17	46	57	170	56						
Gross output at basic prices	**121**	**573**	**51**	**187**	**343**	**323**	**535**	**524**						

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From IO-table to IO-model: two industries and private consumption

	Agriculture	Manu-facturing	Private consump-tion	Total Output
Agriculture	1	9	10	20
Manufacturing	8	2	13	23
Value added	11	12		
Total input	20	23		

Two equations:

1 + 9 + 10 = 20

8 + 2 + 13 =23

Using symbols:

	Agriculture	Manu-facturing	Private consump-tion	Total Output
Agriculture	B11	B12	Y1	X1
Manufacturing	B21	B22	Y2	X2
Value added	V1	V2		
Total input	X1	X2		

Two equations:

$B_{11} + B_{12} + Y_1 = X_1$

$B_{21} + B_{22} + Y_2 = X_2$

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From IO-table to IO-model: two industries and private consumption

	Agriculture	Manu-facturing	Private consump-tion	Total Output
Agriculture	B11	B12	Y1	X1
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Value added	V1	V2		
Total input	X1	X2		

Two equations:

$B_{11} + B_{12} + Y_1 = X_1$

$B_{21} + B_{22} + Y_2 = X_2$

equal to:

$(B_{11}/X_1)*X_1 + (B_{12}/X_2)*X_2 + Y_1 = X_1$

$(B_{21}/X_1)*X_1 + (B_{22}/X_2)*X_2 + Y_2 = X_2$

equal to:

$A_{11}*X_1 + A_{12}*X_2 + Y_1 = X_1$

$A_{21}*X_1 + A_{22}*X_2 + Y_2 = X_2$

Where A_{ij} are the input-output coefficents B_{ij}/X_j

Input-output model

$$A_{11}*X_1 + A_{12}*X_2 + Y_1 = X_1$$
$$A_{21}*X_1 + A_{22}*X_2 + Y_2 = X_2$$

using matrix notation: $\underline{AX + Y = X}$

Generalised input-output model, n industries

$AX + Y = X$

(Input-output coefficients * output) plus final use = output

$X - AX = Y$

$(I - A)X = Y$

$X = (I - A)^{-1} \bullet Y$ which is the IO-model

It calculates the total output, X, needed for a certain final use, Y (e.g. private consumption) by multiplying the Leontieff inverse $(I-A)^{-1}$ by the final use.

It takes all deliveries between industries into account

Environmental-extended input-output model

Once the output X needed for a certain final use has been estimated it is possible to estimate employment, energy use, water use, air emissions etc.

For instance, from the emissions accounts we first estimate emissions intensities, i.e. how much air emissions is on average generated in industries:

Emission intensity, e_i, for industry *i* is total emission E_i divided by output X_i:

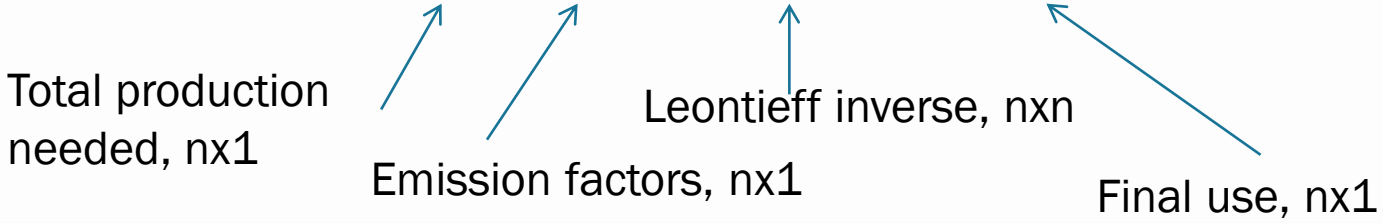
- $e_i = E_i / X_i$ matrix notation

Environmental-extended input-output model

- From the IO-model and the emissions coefficients we estimate the air emissions corresponding to a certain final use.

Total air emissions from production in industries needed to satisfy the final demand Y:

$$\text{Air emissions} = X \# EM = (I - A)^{-1} \bullet Y \# EM$$



Example: Consumption of water by industries by final demand that caused them – Denmark 2005

Water consumption by industries 2005.						
	Total	Private consumptio	Government consumptio	Investment, buildings	Investment others	Export
Agriculture	160.368	33.345	1.863	231	-137	122.165
Horticulture, orchards etc.	7.926	3.217	240	46	11	4.272
Agricultural services; lands	912	150	284	115	3	345
Forestry	74	19	8	3	1	26
Fishing	38.776	2.132	312	43	47	36.227
Extr. of crude petroleum, r	2	0	0	0	0	2
Extr. of gravel, clay, stone a	3.254	590	313	842	33	1.373
Production etc. of meat an	36.292	10.012	609	78	124	25.153
Processing etc. of fish and f	8.071	1.582	55	7	13	6.328
Processing etc. of fruit and	4.355	356	55	8	9	3.939
Mfr. of vegetable and anim	1.169	516	36	4	5	601

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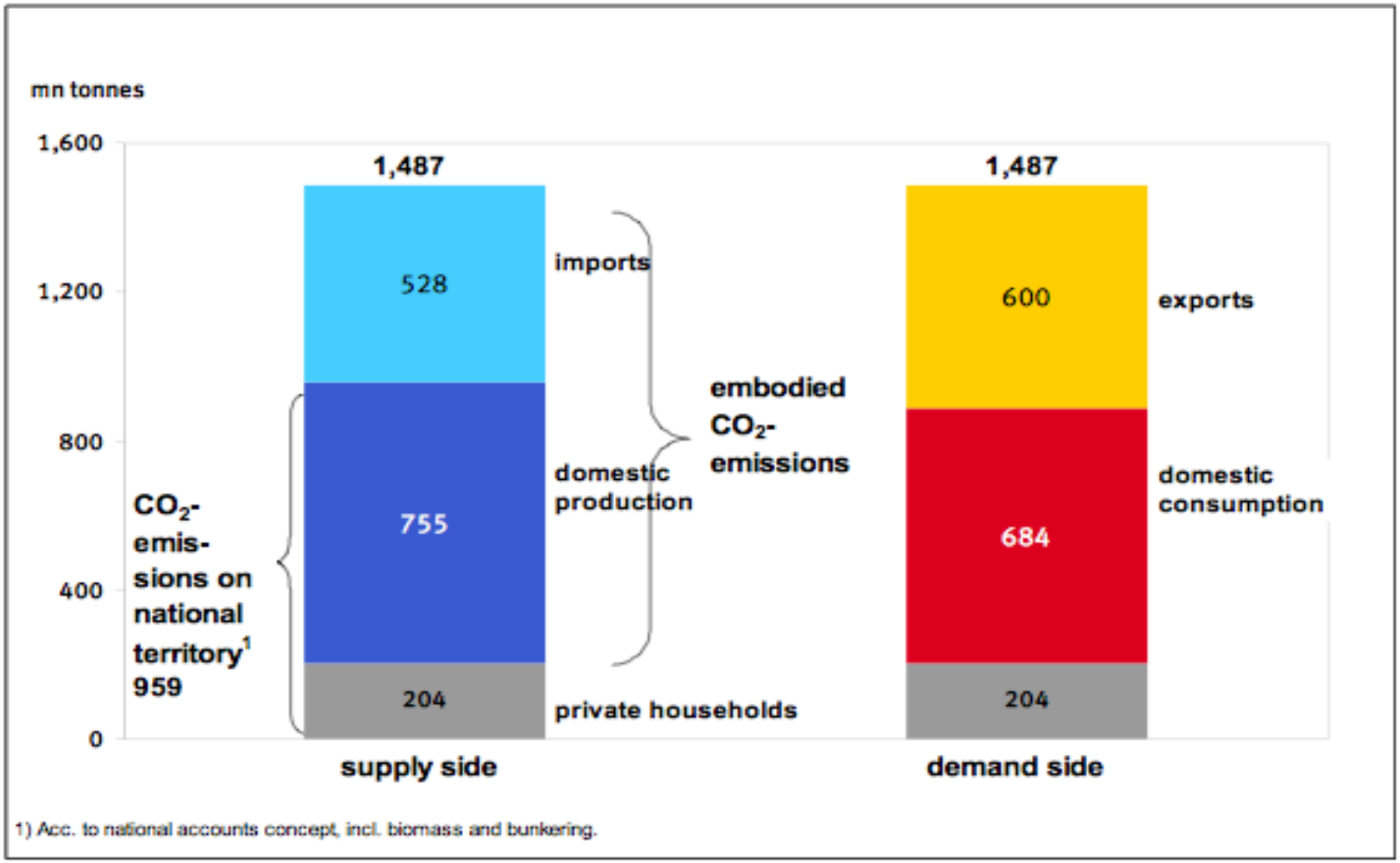
Example: CO2 embodied in Danish exports and imports

	CO2 balance for Danish foreign trade
	1000 tonnes CO_2
Emissions embodied in exports	20,368
Emissions embodied in imports	26,795
Surplus on CO_2 balance	-6,427

Diagram 3: CO_2 emissions and embodied CO_2 in Germany 2007



1) Acc. to national accounts concept, incl. biomass and bunkering.

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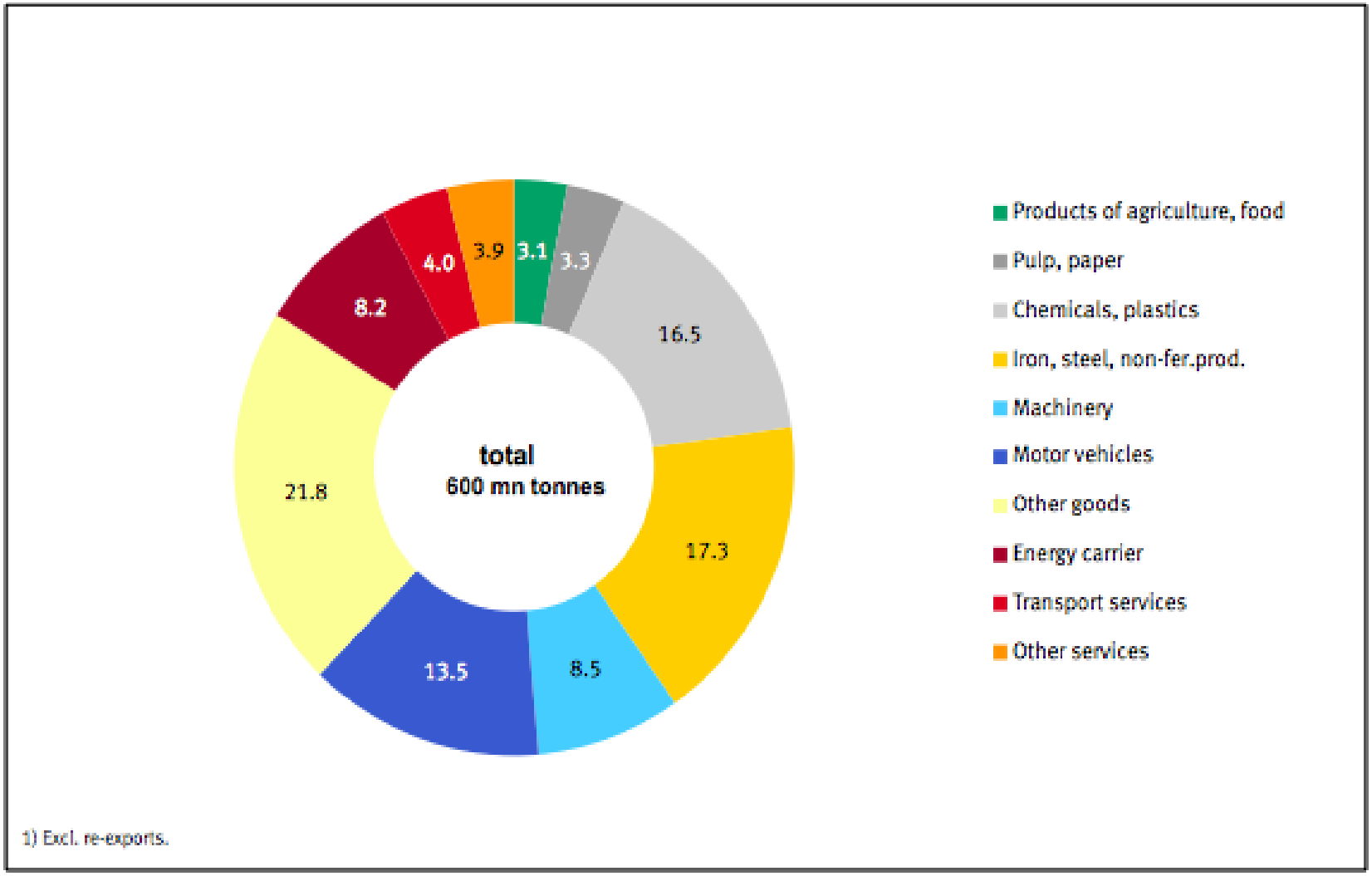
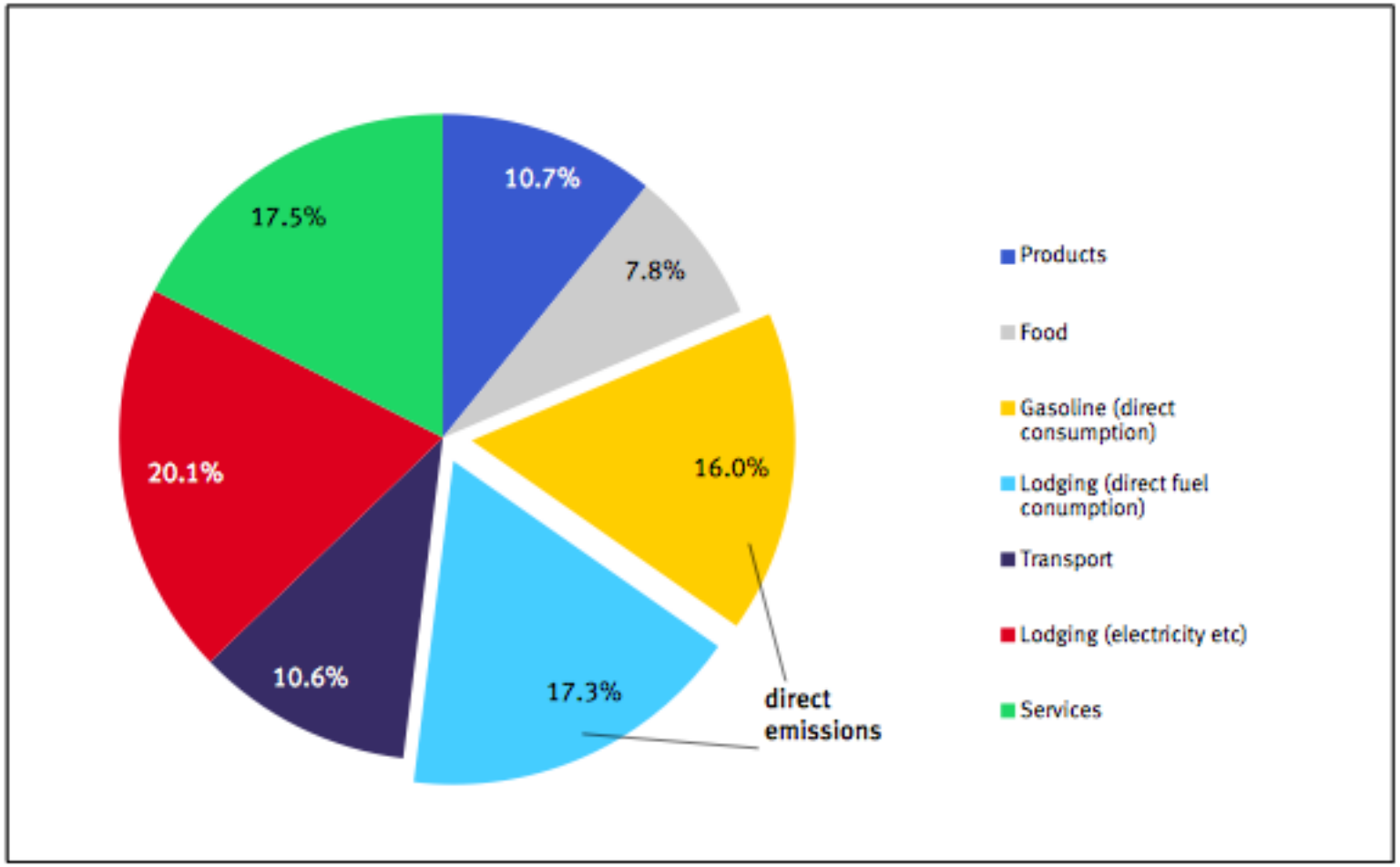
Diagram 8: CO_2 emissions of exports by type of goods 2007 (percentage)



1) Excl. re-exports.

Diagram 10: CO_2 emissions of private households and embodied CO_2 of consumer goods 2007 (percentage)



THANK YOU

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